REMARKS

The present Amendment amends claims 34 and 53, and leaves claims 35-52 and 54-60 unchanged. Therefore, the present application has pending claims 34-60.

35 U.S.C. §102 Rejections

Claims 34-36, 38, 42, 44, and 54-60 stand rejected under 35 U.S.C. §102(e) as being unpatentable over U.S. Patent Application Publication No. 2001/0054771 to Wark, et al. ("Wark"). This rejection is traversed for the following reasons. Applicants submit that features of the present invention, as now more clearly recited in claims 34-36, 38, 42, 44, and 54-60, are not taught or suggested by Wark, whether taken individually or in combination with the other references of record. Therefore, Applicants respectfully request the Examiner to reconsider and withdraw this rejection

Amendments were made to the claims to more clearly describe features of the present invention. Specifically, amendments were made to the claims to more clearly describe that the present invention is directed to a method of producing a semiconductor device as recited, for example, in independent claim 34.

The present invention, as recited in claim 1, provides a method of producing a semiconductor device, including the steps of forming a plurality of pyramid-shaped bump electrodes, and connecting the pyramid-shaped electrodes to pad electrodes of the semiconductor device. The step of forming the plurality of pyramid-shaped bump electrodes includes forming pyramid-shaped etched holes by anisotropically etching a base material having a crystal orientation, and filling up the etched pyramid-shaped holes by plating a metal to form the pyramid-shaped bump

electrodes, where the shape of the pyramid-shaped bump electrodes is identical to the shape of the etched pyramid-shaped holes. The step of connecting the pyramid-shaped bump electrodes to the pad electrodes includes attaching the base of the pyramid-shaped bump electrodes to the pad electrodes, and transferring the pyramid-shaped bump electrodes to the pad electrodes. Also, according to the present invention, the pyramid-shaped bump itself is formed by a conductive material. The prior art does not disclose all these features.

The above described features of the present invention, as now more clearly recited in the claims, are not taught or suggested by any of the references of record, particularly Wark, whether taken individually or in combination with the other references of record.

Wark discloses a method for making projected contact structures for engaging bumped semiconductor devices. However, there is no teaching or suggestion in Wark of the method of producing a semiconductor device of the present invention, as recited in the claims.

Wark teaches a bumped semiconductor device contact structure including at least one non-planar contact pad having a plurality of projections extending from the contact pad. The projections contact at least one solder ball of a bumped integrated circuit (IC) device, such as a bumped die and a bumped packaged IC device. The projections are arranged to make electrical contact with the solder balls of a bumped IC device without substantially deforming the solder ball. Accordingly, reflow of solder balls to reform the solder balls is not necessary with the contact pad of Wark.

Wark further discloses a method for forming the contact pads by etching a deposition.

To further illustrate distinguishing features between the present invention and Wark, the Examiner's attention is directed to the following discussion. The present invention includes pyramid-shaped holes formed by anisotropic etching of base material, filling up conductive material into the pyramid-shaped hole, to obtain the pyramid-shaped bump made of conductive material of which shape is formed by eliminating the base material. As a result of the unique fabricating method of the present invention, it becomes possible to support a narrower pitch of an electrode pad.

In Wark, to the contrary, the base substrate is anisotropically etched, and a protrusion (not hole) is formed in the base substrate itself. In addition, to add conductivity, a structure is proposed which provides conductive material on the surface of the protrusion. However, by the fabricating method of Wark, even where the protrusion is obtained by anisotropic etching, it becomes necessary for depositing conductive material afterward. Therefore, the shape of protrusion is altered such that Wark does not achieve a narrower pitch, as in the present invention, because the distance to the adjacent bump becomes narrower by the deposited conductive material. Furthermore, in Wark, it is necessary to carry out deposition in the final processing, and the height of each bump becomes dispersed.

Paragraph [0052] in Wark cited by the Examiner merely discloses forming a protrusion by anisotropic etching the base substrate (anisotropic etching the periphery of a portion which becomes the protrusion). Therefore, Wark is completely

different from the present invention in which a pyramid-shaped hole is formed. Accordingly, Wark discloses nothing more than forming a shape of a protrusion by undercutting (i.e., remains mask to protrusion forming portion, and eliminating all the base substrate by etching which becomes a base other than where the mask is formed).

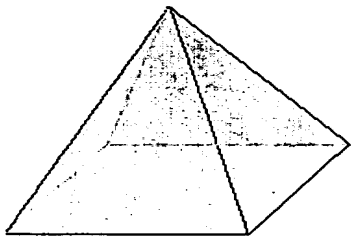
Furthermore, although the term "plating" is disclosed in Wark (see paragraph [0019]), there is no disclosure whatsoever of filling up a pyramid-shaped hole with a conductive material, as in the present invention.

As previously discussed, this invention discloses the formation of a pyramid-shaped bump with a conductive material by forming a hole shape by way of anisotropic etching. As a result, the present invention is without dispersion in heights, without defective continuity in connecting with the base substrate. In addition, in the present invention, a pyramid-shaped solder bump of fair shape and a high positional precision can be formed. On the other hand, the bump of Wark, after forming a protrusion from the base material, a conductive layer is formed on its surface, dispersion in heights occurs easily, its corner shape becomes altered, and defective continuity occurs easily.

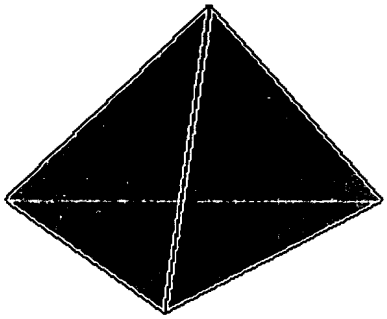
The above unique structure of the present invention is not disclosed in either of paragraphs [0052], [0059] or [0019], or in any other portions of Wark. Specific distinguishing features, as recited in the claims, are outlined as follows.

One feature of the present invention, as recited in claim 34, includes forming a plurality of pyramid-shaped bump electrodes. Wark does not disclose this feature.

As shown below, a pyramid is defined as a space figure having a square base and 4 triangle-shaped sides.



The present invention discloses the use of pyramid-shaped bump electrodes. Wark does not disclose the use of pyramid-shaped bump electrodes. To the contrary, and as shown in Fig. 1A (item 24), Fig. 2B (item 48) and Fig. 12 (item 510), Wark discloses the use of tetrahedron-shaped projections. As shown below, a tetrahedron is defined as a space figure having 4 sides, where each of the 4 sides is a triangle.



A pyramid-shaped bump electrode, as disclosed in the present invention, is not the same as a tetrahedron-shaped bump electrode, as disclosed in Wark.

Furthermore, a "triangular or pyramid-like" projection is not the same as a "pyramid-shaped" bump electrode. With reference to Fig. 1A, Wark describes the projections 24 as "triangular or pyramid-like" structures (paragraph [0042]). A triangular or pyramid-like structure is not the same as the actual shape of a pyramid,

as in the present invention. To the contrary, a triangular or pyramid-like structure is an accurate description of the tetrahedron-shaped projections shown in Fig. 1A. In addition, it is clear that Wark intends to describe the projections 24 shown in Fig. 1A as triangular or pyramid-like based on the choice of language (i.e., "the projections 24, (here seen as radially extending, triangular or pyramid-like structures)) (paragraph [0042]).

In response to Applicants' arguments, the Examiner contends that "Wark clearly teaches pyramidal-shaped bump electrodes of the semiconductor device," citing Figs. 2A, 2B and 8D, and paragraph [0046]. However, Applicants respectfully disagree. Regarding Fig. 8D, this is clearly not a pyramid-shaped electrode because the base of the structure 204, as shown and described in the accompanying text, is a trapezoid — not a square base as in a pyramid-shaped electrode, as claimed. Furthermore, regarding Figs. 2A and 2B, those figures must be considered together, within the context of the accompanying text at paragraph [0046]. For example, as clearly described in paragraph [0046], Figs. 2A and 2B illustrate where the contact structure 40 includes a plurality of knife-like projections 42, where the knife-like projections 42 are adjoined to form a frame-like receptacle for receiving a solder ball 44 there between. Neither of the knife-like projections, the solder ball, or the contact structure 40 has a square base having triangular sides, to form a pyramid-shaped bump electrode, as claimed. Therefore, Wark does not teach or suggest the claimed feature.

Another feature of the present invention, as recited in claim 34, includes where the step of forming the plurality of pyramid-shaped bump electrodes includes

forming pyramid-shaped etched holes by anisotropically etching a base material having a crystal orientation, and filling up the etched pyramid-shaped holes by plating a metal to form the pyramid-shaped bump electrodes, where the shape of the pyramid-shaped bump electrodes is identical to the shape of the etched pyramid-shaped holes. To support the assertion that Wark teaches forming etched holes by anisotropically etching a base material having a crystal orientation, the Examiner cites paragraph [0052]. However, there is no teaching or suggestion in the cited paragraph, or any other portions of Wark of anisotropically etching a base material to form pyramid-shaped etched holes, as in the present invention. To support the assertion that Wark teaches filling up the etched holes to form the electrodes, the Examiner cites paragraph [0019], and cites paragraph [0059] to support the assertion that the shape of the pyramid-shaped electrodes is identical to a shape of the etched pyramid-shaped holes, as claimed. However, Wark does not at all teach the formation of pyramid-shaped electrodes. Accordingly, Wark does not disclose etched pyramid-shaped holes, and further does not disclose where the pyramid-shaped bump electrodes take on the shape identical to the etched pyramid-shaped holes.

In response to Applicants' arguments, the Examiner merely rehashes the rejection as was previously described in the Office Action. Therefore, the Examiner has not provided any indication to Applicants as to why Applicants' arguments are not persuasive. If the Examiner persists in this rejection, Applicants respectfully request the Examiner to provide specific reasons that more clearly point out why the Examiner is not persuaded by Applicants arguments.

Yet another feature of the present invention, as recited in claim 34, includes where the step of connecting the pyramid-shaped bump electrodes to the pad electrodes includes attaching the base of the pyramid-shaped bump electrodes to the pad electrodes, and transferring the pyramid-shaped bump electrodes to the pad electrodes. Wark does not disclose this feature. To support the assertion that Wark discloses connecting bump electrodes to pad electrodes, the Examiner cites Fig. 1A (items 22 and 24), Fig. 1B (items 24 and 26), Fig. 2B (items 42 and 48) and Fig. 12 (items 508 and 510). However, as previously discussed, Wark does not disclose where the connecting pyramid-shaped bump electrodes to pad electrodes, as claimed. To the contrary, Wark discloses the use of tetrahedron-shaped projections rather than pyramid-shaped bumped electrodes, as in the present invention. Furthermore, Wark does not teach or suggest where the step of connecting the pyramid-shaped bump electrodes to the pad electrodes includes attaching the base of the pyramid-shaped bump electrodes to the pad electrodes, and transferring the pyramid-shaped bump electrodes to the pad electrodes, in the manner claimed.

In response to Applicants' arguments, the Examiner merely rehashes the rejection as was previously described in the Office Action. Therefore, the Examiner has not provided any indication to Applicants as to why Applicants' arguments are not persuasive. If the Examiner persists in this rejection, Applicants respectfully request the Examiner to provide specific reasons that more clearly point out why the Examiner is not persuaded by Applicants arguments.

Still yet another feature of the present invention, as recited in claim 34, includes where the pyramid-shape bump electrodes themselves are each formed of

a conductive material. Wark does not disclose this feature. To the contrary, the bump in Wark is formed by depositing a conductive material onto the surface of the protrusion, which is formed by silicon. More specifically, Wark discloses where the bump is a silicon material (inside), which has a conductive material deposited on its surface.

Therefore, Wark fails to teach or suggest "forming a plurality of pyramid-shaped bump electrodes of the semiconductor device" as recited in claim 34.

Furthermore, Wark fails to teach or suggest "wherein said step of forming the plurality of pyramid-shaped bump electrodes includes: a step of forming pyramid-shaped etched holes by anisotropically etching a base material having a crystal orientation, and a step of filling up the etched pyramid-shaped holes by plating a metal to form the pyramid-shaped bump electrodes, wherein the shape of the pyramid-shaped bump electrodes is identical to a shape of the etched pyramid-shaped holes" as recited in claim 34.

Yet even further, Wark fails to teach or suggest "wherein the step of connecting the pyramid-shaped bump electrodes to the pad electrodes includes: a step of attaching the base of the pyramid-shaped bump electrodes to the pad electrodes, and a step of transferring the pyramid-shaped bump electrodes to the pad electrodes" as recited in claim 34.

Still even further, Wark fails to teach or suggest "wherein the pyramid-shaped bump electrodes are each formed of a conductive material" as recited in claim 34.

Therefore, Wark fails to teach or suggest the features of the present invention, as now more clearly recited in the claims. Accordingly, reconsideration and

withdrawal of the 35 U.S.C. §102(e) rejection of claims 34-36, 38, 42, 44, and 54-60 are respectfully requested.

The remaining references of record have been studied. Applicants submit that they do not supply any of the deficiencies noted above with respect to the references used in the rejection of claims 34-36, 38, 42, 44, and 54-60.

35 U.S.C. §103 Rejections

Claims 37, 39-41, 43, and 45-53 stand rejected under 35 U.S.C. §103(a) as being unpatentable over Wark in view of U.S. Patent No. 5,643,831 to Ochiai, et al. ("Ochiai"). Claims 37, 39-41, 43, and 45-52 are dependent on claim 34. Therefore, Applicants submit that claims 37, 39-41, 43, and 45-52 are allowable for at least the same reasons as independent claim 34. Regarding the remaining claim 53, this rejection is traversed for the following reasons. Applicants submit that the features of the present invention, as now more clearly recited in claim 53, is not taught or suggested by either Wark or Ochiai, whether taken individually or in combination with each other as suggested by the Examiner. Therefore, Applicants respectfully request the Examiner to reconsider and withdraw this rejection.

Amendments were made to the claims to more clearly describe the features of the present invention. Specifically, the claims were amended to more clearly describe that the present invention is directed to a method of producing a semiconductor device as recited, for example, in independent claim 53.

The present invention, as recited in claim 53, provides a method of producing a semiconductor device including forming a plurality of pyramid-shaped bump electrodes and connecting the pyramid-shaped bump electrodes to pad electrodes of

the semiconductor device. The step of forming the plurality of pyramid-shaped electrodes includes forming a first pattern having openings at positions corresponding to etched holes by etching a first oxidized film formed on a surface of abase material having a crystal orientation, and forming the etched holes by using the first pattern as a mask. The step of forming the plurality of pyramid-shaped electrodes further includes removing the first oxidized film and forming a second oxidized film anew on the etched holes. Also includes in the step of forming the plurality of pyramid-shaped electrodes is a step of forming a plated feeding film on the base material having the crystal orientation and on a side surface of each of the etched holes. The step of forming the pyramid-shaped electrodes also includes forming a second pattern of an organic material on the base material having the crystal orientation, so that the etched holes are not covered, and filling up the etched holes by plating a metal film on the plated film on the plated feeding film. The step of forming the pyramid-shaped electrodes further includes forming a gold plated film on the metal film and removing the second pattern of the organic material. The method of the present invention also includes where the step of connecting the pyramid-shaped bump electrodes to the pad electrodes includes attaching the base of the pyramid-shaped bump electrodes to the pad electrodes, and transferring the pyramid-shaped bump electrodes to the pad electrodes. The prior art does not disclose all these features.

The above described features of the present invention, as now more clearly recited in the claims, are not taught or suggested by any of the references of record.

Specifically, the features are not taught or suggested by either Wark or Ochiai, whether taken individually or in combination with each other.

As previously discussed, Wark discloses a method for making projected contact structures for engaging bumped semiconductor devices. However, there is no teaching or suggestion in Wark of the method of producing a semiconductor device of the present invention, as recited in the claims.

One feature of the present invention, as recited in claim 53, includes forming a plurality of pyramid-shaped bump electrodes. As previously discussed, Wark does not disclose the use of pyramid-shaped bump electrodes. To the contrary, and as shown in Fig. 1A (item 24), Fig. 2B (item 48) and Fig. 12 (item 510), Wark discloses the use of tetrahedron-shaped projections. These tetrahedron-shaped projections are not the same as the pyramid-shaped bump electrodes of the present invention.

Another feature of the present invention, as recited in claim 53, includes where the step of connecting the pyramid-shaped bump electrodes to the pad electrodes includes attaching the base of the pyramid-shaped bump electrodes to the pad electrodes, and transferring the pyramid-shaped bump electrodes to the pad electrodes. Wark does not disclose this feature. To support the assertion that Wark discloses connecting bump electrodes to pad electrodes, the Examiner cites Fig. 1A (items 22 and 24), Fig. 1B (items 24 and 26), Fig. 2B (items 42 and 48) and Fig. 12 (items 508 and 510). However, as previously discussed, Wark does not disclose where the connecting pyramid-shaped bump electrodes to pad electrodes, as claimed. To the contrary, Wark discloses the use of tetrahedron-shaped projections rather than pyramid-shaped bumped electrodes, as in the present invention.

Furthermore, Wark does not teach or suggest where the step of connecting the pyramid-shaped bump electrodes to the pad electrodes includes attaching the base of the pyramid-shaped bump electrodes to the pad electrodes, and transferring the pyramid-shaped bump electrodes to the pad electrodes, in the manner claimed.

Still yet another feature of the present invention, as recited in claim 53, includes where the pyramid-shape bump electrodes themselves are each formed of a conductive material. Wark does not disclose this feature. To the contrary, the bump in Wark is formed by depositing a conductive material onto the surface of the protrusion, which is formed by silicon. More specifically, Wark discloses where the bump is a silicon material (inside), which has a conductive material deposited on its surface.

Therefore, Wark fails to teach or suggest "forming a plurality of pyramid-shaped bump electrodes of the semiconductor device" as recited in claim 53.

Furthermore, Wark fails to teach or suggest "wherein the step of connecting the pyramid-shaped bump electrodes to the pad electrodes includes: a step of attaching the base of the pyramid-shaped bump electrodes to the pad electrodes, and a step of transferring the pyramid-shaped bump electrodes to the pad electrodes" as recited in claim 53.

Still even further, Wark fails to teach or suggest "wherein the pyramid-shaped bump electrodes are each formed of a conductive material" as recited in claim 53.

The above noted deficiencies of Wark are not supplied by any of the other references, particularly Ochiai. Therefore, combining the teaching of Ochiai with

Wark still fails to teach or suggest the features of the present invention, as now more clearly recited in claim 53.

Ochiai discloses a process for forming solder balls on a plate having apertures using solder paste and transferring the solder balls to the semiconductor device. However, there is no teaching or suggestion in Ochiai of the method of producing a semiconductor device of the present invention, as recited in claim 53.

In Ochiai's method, a semiconductor is fabricated using a solder ball forming plate having cavities. The plate is made from a silicon plate having a flat surface in a crystallographic plane, and an orientation flat in a crystallographic plane. The cavities are formed on the flat surface of the plate by etching, using a mask having openings in the shape of a rhombus, arranged such that one side of the rhombus is generally parallel to the crystallographic plane. As a result, the cavities having a wedge-shaped bottom are formed. The cavities are then filled with a solder paste and are heated to from solder balls in the cavities while the plate is in an inclined position. The solder balls are then transferred from the plate to the semiconductor chip.

One feature of the present invention, as recited in claim 53, includes forming a plurality of pyramid-shaped bump electrodes. Ochiai does not disclose this feature. As shown and described, Ochiai discloses the formation of solder balls, which are quite different from the pyramid-shaped bump electrodes of the present invention.

Another feature of the present invention, as recited in claim 53, includes where the step of connecting the pyramid-shaped bump electrodes to the pad electrodes includes attaching the base of the pyramid-shaped bump electrodes to

the pad electrodes, and transferring the pyramid-shaped bump electrodes to the pad electrodes. Ochiai does not disclose this feature. As previously discussed, Ochiai does not teach or suggest the formation of pyramid-shaped bump electrodes, as in the present invention. Therefore, Ochiai does not teach or suggest connecting pyramid-shaped bump electrodes to pad electrodes, in the manner claimed.

Still yet another feature of the present invention, as recited in claim 34, includes where the pyramid-shape bump electrodes themselves are each formed of a conductive material. Ochiai does not disclose this feature. Ochiai does not teach or suggest forming pyramid-shaped electrodes. Therefore, it follows that Wark does not teach or suggest pyramid-shaped bump electrodes formed of conductive material, in the manner claimed.

Therefore, Ochiai fails to teach or suggest "forming a plurality of pyramid-shaped bump electrodes of the semiconductor device" as recited in claim 53.

Furthermore, Ochiai fails to teach or suggest "wherein the step of connecting the pyramid-shaped bump electrodes to the pad electrodes includes: a step of attaching the base of the pyramid-shaped bump electrodes to the pad electrodes, and a step of transferring the pyramid-shaped bump electrodes to the pad electrodes" as recited in claim 53.

Still even further, Ochiai fails to teach or suggest "wherein the pyramid-shaped bump electrodes are each formed of a conductive material" as recited in claim 53.

Both Wark and Ochiai suffer from the same deficiencies relative to the features of the present invention, as recited in the claims. Therefore, combining the

teachings of Wark and Ochiai, in the manner suggested by the Examiner, does not render obvious the features of the present invention, as now more clearly recited in claim 53. Accordingly, reconsideration and withdrawal of the 35 U.S.C. §103(a) rejection of claim 53 as being unpatentable over Wark in view of Ochiai is respectfully requested.

The remaining references of record have been studied. Applicants submit that they do not supply any of the deficiencies noted above with respect to the references used in the rejection of claim 53.

In view of the foregoing amendments and remarks, Applicants submit that claims 34-60 are in condition for allowance. Accordingly, early allowance of claims 34-60 is respectfully requested.

To the extent necessary, Applicants petition for an extension of time under 37 CFR 1.136. Please charge any shortage in fees due in connection with the filing of this paper, including extension of time fees, or credit any overpayment of fees, to the deposit account of Mattingly, Stanger, Malur & Brundidge, P.C., Deposit Account No. 50-1417 (referencing attorney docket no. 500.38090X00).

Respectfully submitted,

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